COMP30024 Artificial Intelligence

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Intelligent Agent

- **Agent model** characterize requirements for an agent in terms of its percepts, actions, environment and performance measure
- **Agent types** choose and justify choice of agent type for a given problem
- **Environment types** characterize the environment for a given problem

Outline

- Defining AI
- Tests for intelligence
- State of the art
- Agent model
- Agent types
- Environment types

Solving By Search

Problem formulation usually requires abstracting away real-world details to define a state space that can feasibly be explored Variety of uninformed search strategies. **Iterative deepening** search uses only linear space and not much more time than other uninformed algorithms

Outline

- Problem-solving agents
- Problem types
- Problem formulation
- Example problems
- Basic search algorithms

Expectations

1. Formulate single-state search problem
2. Apply a search strategy to solve problem
3. Analyse complexity of a search strategy

Informed Search

Heuristics help reduce search cost, however, finding an optimal solution is still difficult.

- **Greedy best-first search** is not optimal, but can be efficient.
- **A* search** is complete and optimal, but is prohibitive in memory.
- **Hill-climbing** methods operate on complete-state formulations,require less memory, but are not optimal.

Outline

- Best-first search
- A∗search
- Heuristics
- Hill-climbing

Expectations

1. Demonstrate operation of search algorithms
2. Discuss and evaluate the properties of search algorithms
3. Derive and compare heuristics for a problem

Game Playing & Adversarial Search

Games illustrate several important points about AI

- perfection is unattainable⇒must approximate and make trade-offs
- uncertainty limits the value of look-ahead
- can programs learn for themselves as they play? (cont. ML for Game Playing)

Outline

- Perfect play
- Resource limits
- $α−β$ pruning
- Games of chance

Expectations

1. Demonstrate operation of game search algorithms
2. Discuss and evaluate the properties of game search algorithms
3. Design suitable evaluation functions for a gam
4. Explain how to search in nondeterministic games

Machine Learning for Game Playing

Many design decisions need to be fine-tuned in game playing agents Can we automatically tune these decisions?

Outline

- Supervised learning using **gradient decent search**
    - **Delayed reinforcement**: reward resulting from an action may not be received until several time steps later, which also slows down the learning
    - **Credit assignment**: need to know which action(s) was responsible for the outcome
- **Temporal difference** learning in games
- **Book learning**: learn sequence of moves for important positions
- **Search control learning**: learn how to make search more efficient
- **Learning evaluation function weights**: adjust weights in evaluation function based on experience of their ability to predict the true final utility

Expectation

1. Discuss opportunities for learning in game playing
2. Explain differences between supervised and temporal difference learning
3. I do not expect you to derive or memories the TDLeaf(λ) weight update rule, but if given this rule I may ask you to explain what the main terms mean

Constraint Satisfaction Problem

CSPs are a special kind of problem: - states defined by values of a fixed set of variables - goal test defined by constraints on variable values

Summary

1. **Backtracking**: depth-first search with one variable assigned per node
2. **Variable ordering** and **value selection** *heuristics* help significantly
3. Forward checking prevents assignments that guarantee later failure
4. Constraint propagation (e.g., arc consistency) does additional work to constrain values and detect inconsistencies
5. The CSP representation allows analysis of problem structure
6. Tree-structured CSPs can be solved in linear time
7. Iterative min-conflicts is usually effective in practice

Outline

- CSP examples
- **Backtracking search** for CSPs
- Problem structure and problem decomposition
- Local search for CSPs

Expectation

1. Model a given problem as a CSP
2. Demonstrate operation of CSP search algorithms
    3. Discuss and evaluate the properties of different constraint satisfaction techniques

Complex Decisions - Auctions

Auctions are a mechanism to allocate resources in multi-agent environments Appropriate mechanism design can achieve desirable behavior among selfish agentsTypes of auctions in theoryPractical case studies of on-line auctions

Outline

- Mechanism design for allocating scarce resources
- Properties of auctions
- Types of auctions
- On-line auctions in practice

Expectation

1. Compare and contrast different types of auctions
2. Describe the properties of a given type of auction
3. Select the most appropriate type of auction for a given application

Uncertainty

Probability is a rigorous formalism for uncertain knowledgeJoint probability distribution specifies probability of every atomic eventQueries can be answered by summing over atomic eventsFor nontrivial domains, we must find a way to reduce the joint sizeIndependence and conditional independence provide the tools

Outline

- Uncertainty
- Probability
- Syntax and Semantics
- Inference
- Independence and Bayes' Rule

Expectation

1. Calculate conditional probabilities using inference by enumeration
2. Use conditional independence to simplify probability calculations
3. Use Bayes' rule for solving diagnostic problems

Bayesian Belief System

Bayes nets provide a natural representation for (causally induced)conditional independence Topology + CPTs = compact representation of joint distribution Generally easy for (non)experts to constructExact inference by enumeration Exact inference by variable elimination

Outline

- Syntax
- Semantics
- Exact inference by enumeration
- Exact inference by variable elimination

Expectation

1. Formulate a belief network for a given problem domain
2. Derive expression for joint probability distribution for given belief network
3. Use inference by enumeration to answer a query about simple or conjunctive queries on a given belief network

Robotics

Outline

- Robots, Effectors,and Sensors
- Localization and Mapping
- Motion Planning

Expectation

1. Percepts and actions are both subject to uncertainty.
2. We cannotinterpretourperceptswithouthavinga model of what they mean,and without(partially invalid)assumptions about how they perform.
3. Uncertainty in robot perception.
4. Incremental form of Bayes Law.
5. Motion planning.