Summarization of CS486/686

Wenhu Chen

Lecture 23

Outline

Search Algorithm

Uncertainty Estimation

Decision Theory

Machine Learning

Search Algorithm

Uncertainty Estimation

Decision Theory

Machine Learning

Overview

- How to formulate a search problem?
- What is a search tree?
- What is generic Search algorithm?
- What is DFS and what is BFS?
- What is the space/time complexity of DFS and BFS?
- What is the iterative deepening space complexity?

How to use heuristic search?

- What is LCFS (lowest-cost first)?
- What is GBFS (lowest-heuristic first)?
- What is A* search (combination of two)?

A* Search Algorithm

- Space and Time Complexities.
- Completeness and Optimality.
- Admissible Heuristics $\rightarrow$ Optimality
- Consistent Heuristics $\rightarrow$ Multi-Path Pruning

Summary of Search Strategies

Strategy	Frontier Selection	Halts?	Space	Time
Depth-first	Last node added	No	Linear	Exp
Breadth-first	First node added	Yes	Exp	Exp
Lowest-cost-first	min $cost(n)$	Yes	Exp	Exp
Greedy Best-first	min $h(n)$	No	Exp	Exp
A*	min $cost(n) + h(n)$	Yes	Exp	Exp

Constraint Satisfaction Problem

- Generate-and-Test is way too slow
- Why do We need to model the internal structure of the state?
- What is Backtracking Algorithm?
- What is Arc consistency Algorithm?
- AC-3 Algorithm, using Arc consistency to eliminate Arc
- AC-3 Algorithm complexity

Local Search

- Why do we need local search?
- How do we perform greedy descent?
- How can we avoid local minima?
- What is Simulated Annealing?

Search Algorithm

Uncertainty Estimation

Decision Theory

Machine Learning

Independence

- What is unconditional independence?
- What is conditional independence?
- What is chain rule/product rule/sum rule/bayes rule?
- Universal appraoch to calculate a probability.

Independence

- Given joint probability distribution, derive the independence step by step.
- Why do we need to use Bayesian Networks?
- How can we compute joint probability over a Bayesian Network?

D-Separation

- What is D-Separation Rule 1?
- What is D-Separation Rule 2?
- What is D-Separation Rule 3?
- How do you apply these D-Sesparation rules to understand independence between different nodes?

Constructing Bayesian Network

- Pick an order
- Add nodes to the graph
- Pick the minimum subset as parents
- Form a Bayesian Network

Variable Elimination Algorithm

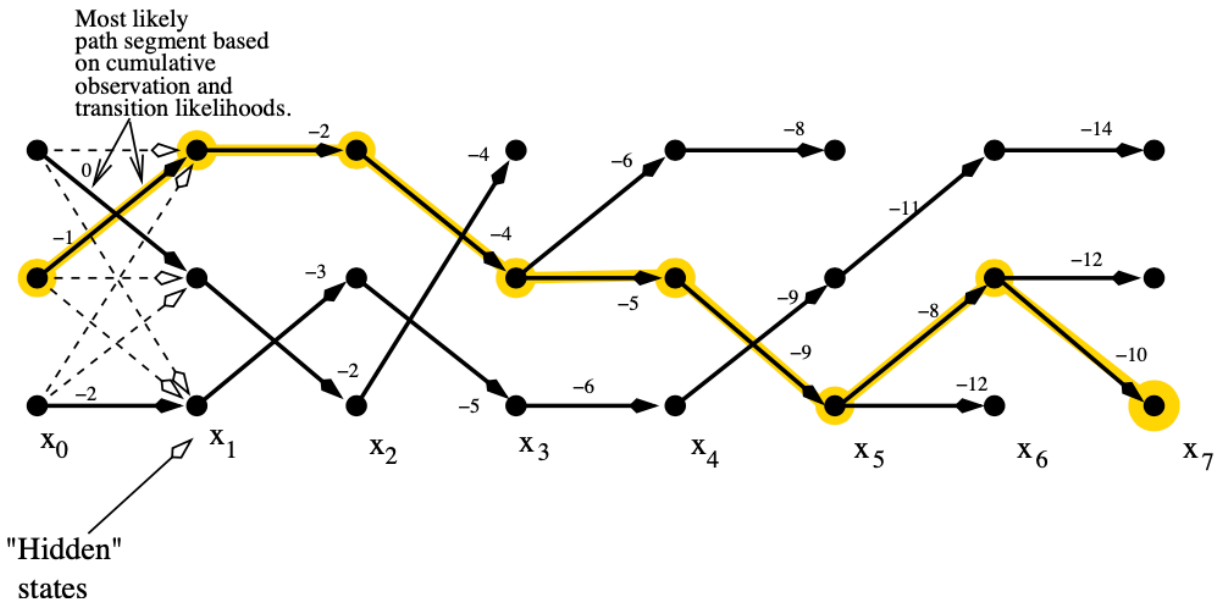
- Define Factors
- Restrict Factors to reflect Evidence
- Multiply factors with shared variables
- Sum out hidden variables
- Normalize to obtain probability

Hidden Markov Model (Smoothing)

- Derive the forward recursion $P(S_k \mid o_{0:k})$
- Compute the forward recursion $P(S_k \mid o_{0:k})$
- Derive the backward recursion $P(o_{k+1:t-1} \mid S_k)$
- Compute the backward recursion $P(o_{k+1:t-1} \mid S_k)$
- Combine forward and backward recurstion to calculate smoothing probability

Viterbi Algorithm

- Dynamic Programming to reuse intermediate variables
- Backtracking to derive the most likely hidden variables



Search Algorithm

Uncertainty Estimation

Decision Theory

Machine Learning

Decision Network

- Understand what is utility.
- Compute expected utility
- Apply Variable Elimination Algorithm in Decision Networks

Markov Decision Process

- What is discounted reward?
- What is policy and value function?
- Bellman equation to update value function.
- Policy iteration to update policy function.

Reinforcement Learning

- How to implement passive ADP?
- How to implement Active ADP?
- How to do Q-Learning?
- What is the difference between ADP and Q-Learning?
- How fast are ADP and Q-Learning?

Supervised Learning

- Classification vs. Regression
- Cross-Validation
- How to avoid Over-fitting?
- Trade-offs between bias and variance.

Unsupervised Learning

- How to do K-means clustering?
- What is Principled component Analysis?
- What is auto-encoder?

Decision Tree

- How to compute entropy?
- How to grow a full tree?
- How to determine the order of testing features?

Neural Networks

- What is activation function and what qualifies as activation functions?
- How to perform back-propagation?
- How to perform gradient descent?
- What are the existing optimizers?

Exam

- Non-programmable calculator
- Two-sided A4 Study Note
- A total of 8 problems
- Tentative: 84 marks, 76+ marks count as 100%
- Tentative: Pass Threshold: 42 marks