Artificial Intelligence

Overview
Instructor

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- Office Hours: Th 2:30-3:30pm
Lectures

• Th 11:45pm – 1:45pm
• 3209
Course website

Prerequisite

- Design and Analysis of Algorithms
- Introduction to Probability and Mathematical Statistics
- Linear Algebra
- All with a grade of C or better
- Programming skills important!
Class Resources

- Artificial Intelligence: Modern Approach (3rd Edition) by Stuart J. Russell, Peter Norvig
- Lecture notes
Grading

- Participation      5%
- Assignments       35%
- Mid-term exams    35%
- Semester project  25%
What is Artificial Intelligence?

- Intelligence in daily life?
What is Artificial Intelligence?

- The science and engineering of making intelligent machines [John McCarthy].
- The scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines [AAAI].
- The study and design of intelligent agents, where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success [Russell & Norvig].
AI Topics

- Agents
- Applications/Expert Systems
- Cognitive Science
- Education
- Ethical & Social
- Games & Puzzles
- History
- Interfaces
- Machine Learning
- Natural Language
- Philosophy
- Reasoning
- Representation
- Robots
- Science Fiction
- Speech
- Systems & Languages
- Turing Test
- Vision
Search Overview

- On holiday in Romania; currently in Arad.
- Flight leaves tomorrow from Bucharest
- Formulate goal:
  - be in Bucharest
- Formulate problem:
  - states: various cities
  - actions: drive between cities
- Find solution:
  - sequence of cities, e.g.,
  - Arad, Sibiu, Fagaras, Bucharest
**A* search**

- **Main idea:** expand paths that seem most promising and avoid paths that are already expensive
- **Use the following evaluation function to guide the search:** \( f(n) = g(n) + h(n) \)
  - \( g(n) \) = cost so far to reach \( n \)
  - \( h(n) \) = estimated cost from \( n \) to goal
  - \( f(n) \) = estimated total cost of path through \( n \) to goal
**A* Path Finding Algorithm**

- [https://www.youtube.com/watch?v=19h1g22hby8](https://www.youtube.com/watch?v=19h1g22hby8) (1:06)
Game Search

- E.g., 2-ply game:
Endgame: Challenging the Masters

- Deep Blue was a chess-playing computer developed by IBM. On May 11, 1997, the machine won a six-game match by two wins to one with three draws against world champion Garry Kasparov.

Uncertainty Reasoning Overview

- **Uncertainty**: The lack of certainty, a state of having limited knowledge where it is impossible to exactly describe existing state or future outcome, more than one possible outcome.

- **Probability**: A measurement of uncertainty; A set of possible states or outcomes where probabilities are assigned to each possible state or outcome – this also includes the application of a probability density function to continuous variables [Wikipedia]
Problem: A screening test has a 90% chance of registering breast cancer if it exists, as well as a 20% chance of falsely registering cancer when it does not exist. About one in one hundred women requesting the screening test end up diagnosed with breast cancer.

Ms. X has just been told that her screening test was positive. What is the probability that she has breast cancer?

Goal: develop methods and algorithms for modeling and reasoning under uncertainty
Uncertainty Reasoning

- **Bayes' rule:**
  \[ P(a \mid b) = \frac{P(b \mid a)P(a)}{P(b)} \]

- Useful for assessing **diagnostic** probability from **causal** probability:
  \[ P(cause \mid effect) = \frac{P(effect \mid cause)P(cause)}{P(effect)} \]
Bayesian networks

![Bayesian network diagram](image)
True Skill

- [Video](http://www.youtube.com/watch?v=b7142mL9-f8) (4:08) [Microsoft]
Hidden Markov Models

Two components:
- A Markov chain of hidden states $H_1, \ldots, H_n$
- Observations $X_1, \ldots, X_n$
Speech Recognition

- Dragon:  
  http://www.youtube.com/watch?v=W3DhnpLIKCQ&feature=related (2:03)

- Microsoft:  
  http://www.youtube.com/watch?v=2Y_Jp6PxsSQ (1:34)
Machine Learning Overview

• Machine learning is a scientific discipline that is concerned with the design and development of algorithms that allow computers to evolve behaviors based on empirical data, such as from sensor data or databases. [Wikipedia]
**Problem:** decide whether to wait for a table at a restaurant, based on the following attributes:

1. Alternate: is there an alternative restaurant nearby?
2. Bar: is there a comfortable bar area to wait in?
3. Fri/Sat: is today Friday or Saturday?
4. Hungry: are we hungry?
5. Patrons: number of people in the restaurant (None, Some, Full)
6. Price: price range ($, $$, $$$)
7. Raining: is it raining outside?
8. Reservation: have we made a reservation?
9. Type: kind of restaurant (French, Italian, Thai, Burger)
10. WaitEstimate: estimated waiting time (0-10, 10-30, 30-60, >60)

**Goal:** Build a machine learning model based on your prior behavior (data) to predict your future decision
Learning

- Simplest form: learn a function from examples

  \( f \) is the target function

  An example is a pair \((x, f(x))\)

  Problem: find a hypothesis \( h \)

  such that \( h \approx f \)

  given a training set of examples
Machine Learning Problem Types

- **Supervised learning** generates a function that maps inputs to desired outputs.
  - For example, in a **classification** problem, the learner approximates a function mapping a vector into classes by looking at input-output examples of the function.

- **Unsupervised learning** models a set of inputs
  - For example, **clustering** is the assignment of a set of observations into subsets (called clusters) so that observations in the same cluster are similar in some sense.

- **Semi-supervised learning** combines both labeled and unlabeled examples to generate an appropriate function or classifier.

- **Reinforcement learning** learns how to act given an observation of the world. Every action has some impact in the environment, and the environment provides feedback in the form of rewards that guides the learning algorithm. [Wikipedia]
Classification

- Mind Reading
  
  http://www.youtube.com/watch?v=jq_nAm4rOu0
  (1:36)
Clustering
Natural language processing

• Natural language processing (NLP) is a field of computer science, artificial intelligence, and computational linguistics concerned with the interactions between computers and human (natural) languages. [Wikipedia]

• Many challenges in NLP involve natural language understanding, that is, enabling computers to derive meaning from human or natural language input, and others involve natural language generation.
Information Retrieval

• IBM Watson
  https://www.youtube.com/watch?v=DywO4zksfXw (6:42)
  http://www.youtube.com/watch?v=Y2wQQ-xSE4s&feature=related (1:50)

• Google search engine
  http://www.youtube.com/watch?v=BNHR6lQJGZs&feature=related (3:15)
Concluding remarks

• Artificial intelligence is a fun topic
  – A lot of practical applications
  – Highly interdisciplinary
  – Lots of AI jobs

• Also, they are not as difficult as you may have thought!