Cooperating Intelligent Systems

Course review

Four main themes

<u>Problem solving by search</u>

- Rational agent
- Uninformed search
- Informed search
- Adversarial search

Ch. 3,4,5,6 ≈ 120 pages

<u>Knowledge and reasoning</u>

- Propositional logic (PL)
- Inference in PL
- First-order logic (FOL)
  (the predicate calculus)
- Inference in FOL

Ch. 7,8,9,10 ≈ 110 pages

<u>Uncertain knowledge</u>

- Probability
- Bayesian networks
- Utility theory

Ch. 13,14 ≈ 50 pages

<u>Learning</u>

- Basic concepts
- Decision trees
- Neural networks
- Support vector machines

Ch. 18,20 ≈ 30 pages

Problem solving by search

- Uninformed: DFS/BFS/IDS
  - Optimality, time/space complexity, ...
- Informed: GBFS/A*/Beam search/GA
  - Heuristic, optimality, proof that A* is optimal
- Adversarial search:
  - Minimax, alpha-beta pruning, chance nodes

Knowledge and reasoning

- Boolean logic
  - Syntax & semantics
  - Inference by enumeration, inference rules, resolution, CNF, Modus Ponens, Horn clauses (forward and backward chaining)
- First-order logic (FOL)
  - Syntax & semantics
  - Quantifiers
  - Lifted inference rules, resolution, CNF

Uncertain knowledge

- Decision theory
- Probability distributions, random variables
- Inference
  - With full joint distribution, Bayes theorem, Naïve Bayes
- Bayesian networks (BN)
  - Definition, construction, d-separation, ...
- Inference in BN
  - Exact, approximate
- Utility

Learning

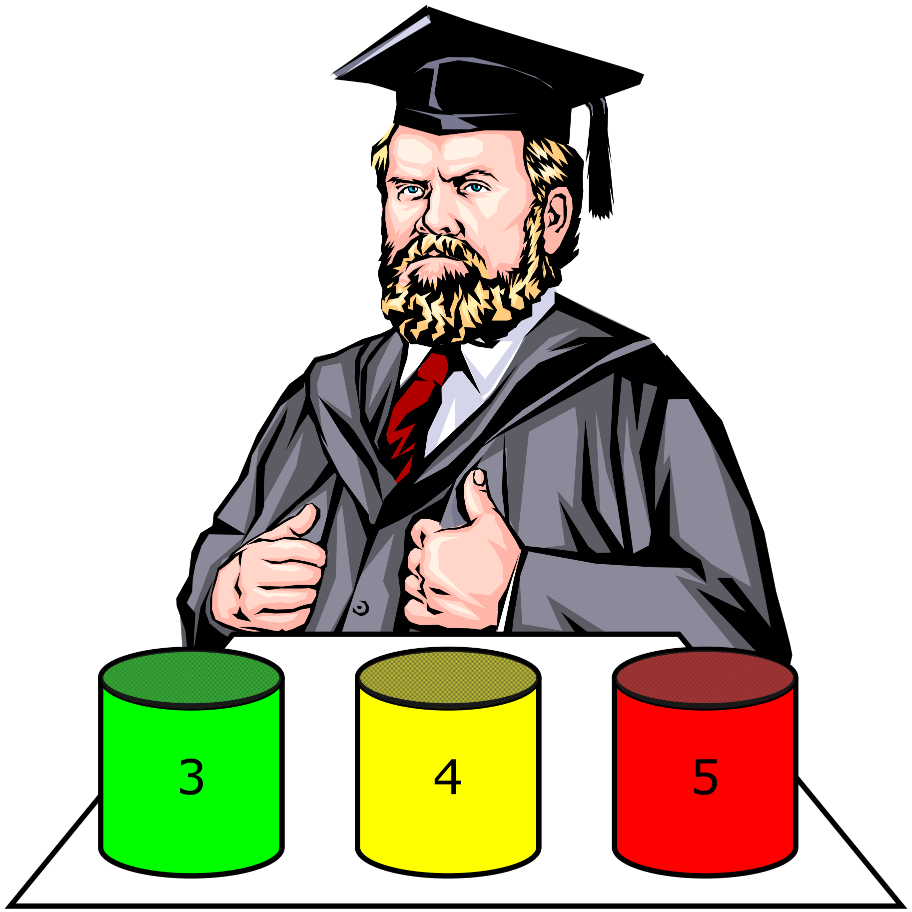
- Inductive learning
  - Overfitting, Ockham's razor, ...
- Decision trees
  - Information measure, ...
- Neural networks
  - Perceptron learning, gradient descent, backpropagation
- Support vector machines
  - Large margin classifier, Kernel trick
- Cross-validation

Written exam

- Written exam on Wednesday 26th of October
- Format:
  - 4 open questions (a bit shorter than on previous years, but similar in spirit)
  - 20 multiple-choice questions
    - +1 point for each correctly answered question
    - -1 point for incorrect answer
- Oral exam planned for Thursday & Friday 27th & 28th of October

The oral exam?

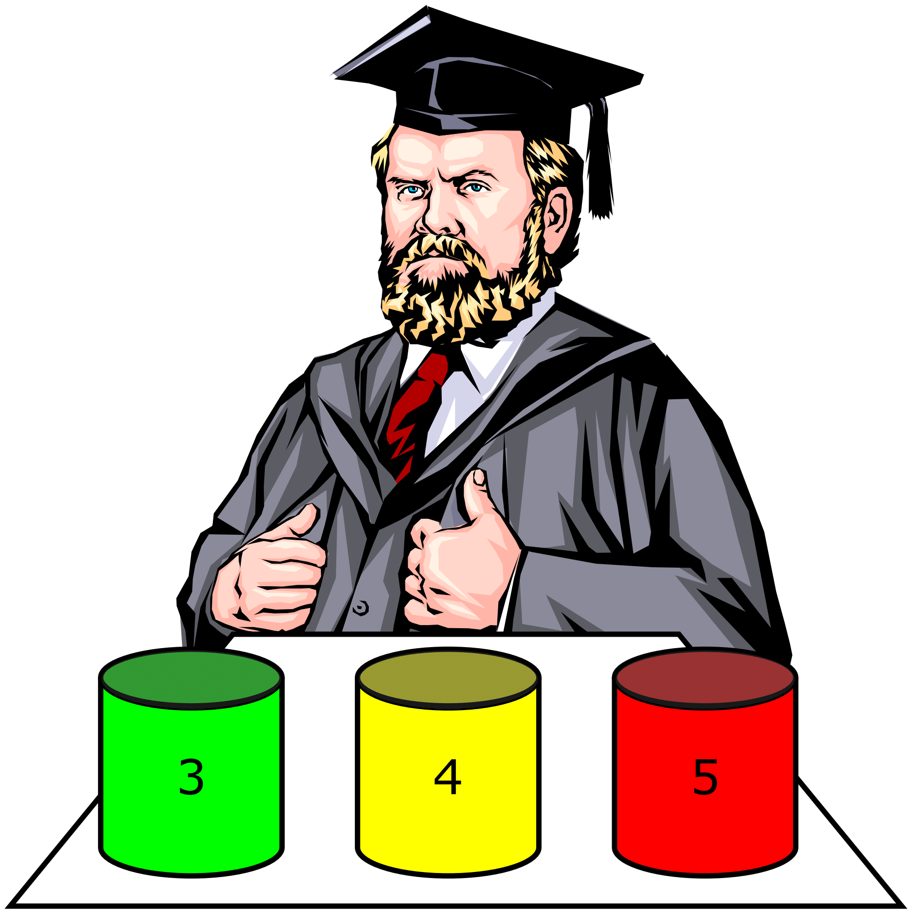
- You start out with a list of written questions (group). You prepare oral answers for these questions.
- You pick a question from an urn of your choice (the questions above will come from the ”easy” section)
  - 3 = easy,
  - 4 = less easy,
  - 5 = difficult
- You answer the question in < 30 minutes (both written and oral presentation)
  - The question can be a composed question
- Points:
  - 3 = 3, 4 = 4, 5 = 5
  - You can be awarded fractions of this.
- Grades:
  - 6-10 points = 3
  - 10-14 points = 4
  - ≥ 15 points = 5



A full set of homework solutions handed in on time starts you at 5 points.
(But you must still answer one question correctly to pass the exam)

The oral exam?

- You start out with a list of 3 written questions.
  - one is trivial,
  - one is easy,
  - one is reasonable.
- You prepare oral answers for these questions – you have 20 minutes for that.
- You answer those questions in any order you wish.
- You can get 0–5 points per question
- You need to get at least 1 point on each question.
- Grades:
  - 7-9 points = 3
  - 10-12 points = 4
  - 13-15 points = 5



Questions?

- Questions will be selected from:
  - The homework
  - The book (AIMA)
  - The lecture slides
  - Our own ideas

Example question (trivial)

The **missionaries and cannibals**: Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people (one for rowing). Find a way to get everyone to the other side, without ever leaving a group of missionaries in one place outnumbered by the cannibals in that place (the cannibals eat the missionaries then).

a. Formulate the problem precisely, making only those distinctions necessary to ensure a valid solution. Draw a diagram of the complete state space.
b. Solve the problem optimally using an appropriate search algorithm. Is it a good idea to check for repeated states?
c. Is there any difference between depth-first and breadth-first here?
d. Why do you think people have a hard time solving this puzzle, given that the state space is so simple?

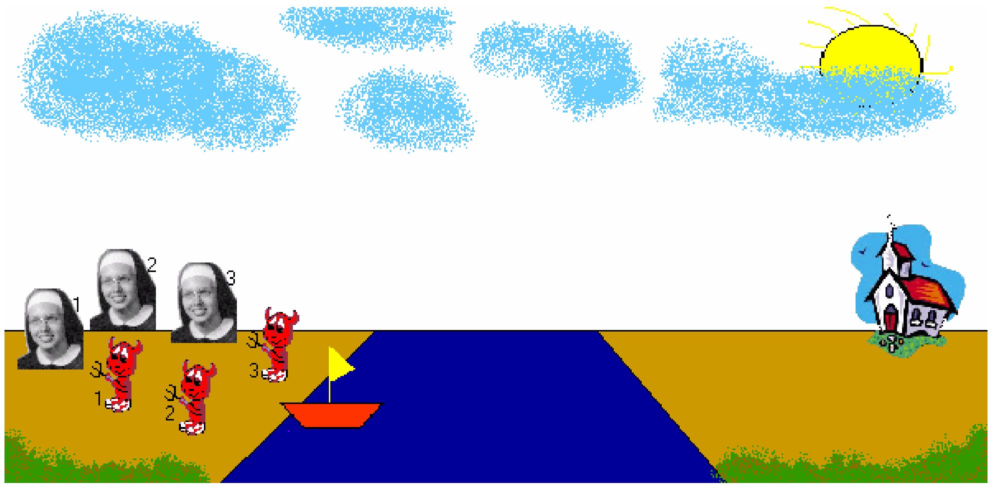


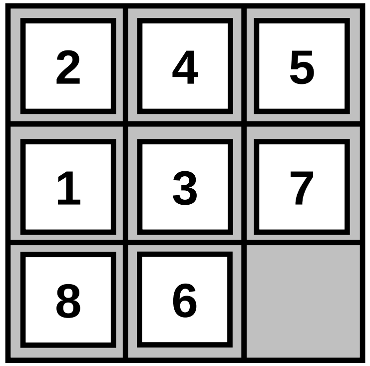
Image from http://www.cse.msu.edu/~michmer3/440/Lab1/cannibal.html

Example question (trivial)

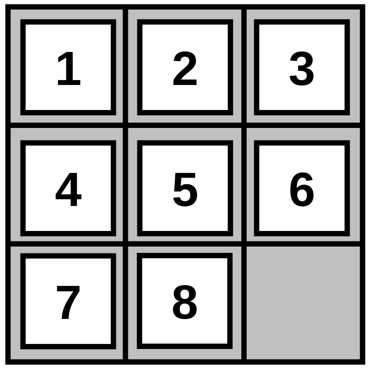
Describe (draw) the complete search tree on how to go from the start position to the end position for the 8-puzzle on the right

What is a good strategy for uninformed search here? Why?

Formulate a heuristic for the search and describe the A* algorithm and how you can use A* to find the solution.



Start



End

Example question (easy)

Describe the A, A*, IDA and SMA algorithms

Prove that A* is an optimal algorithm for both tree search and graph search (state the conditions for this to be true).

Example question (reasonable)

Among its many world-wide effects, the El Niño phenomenon can sometimes lead to a split jet stream over North America. It is also known that split jet streams can lead to wetter winters in the Southwest US. They have also been known to cause drier winters in the Northwest US. Some relevant numbers are:

- El Niños tend to happen once every 10 years
- The chance of a split jet stream given an El Niño event is 0.5
- The chance of a split jet stream without an El Niño is 0.1
- The chance that there will be a wet winter in the SW, given a split jet stream, is 0.5 while it is 0.1 when there is not a split jet stream;
- The chance of a dry winter in the NW, given a split jet stream, is 0.8 and it is 0.1 when there is no split.

a) Draw a Bayesian network that captures these facts complete with all the tables needed to make it work. Explain what a Bayesian network is.

b) Suppose that you are told that there is an El Niño event underway. Calculate what your belief should be that it will be a wet winter in the SW.

c) You next learn that it has in fact been wet in the Southwest. What is your belief that it will be dry in the Northwest?

d) Finally, you learn that there is in fact no split jet stream. Now calculate your belief in a dry winter in the Northwest.

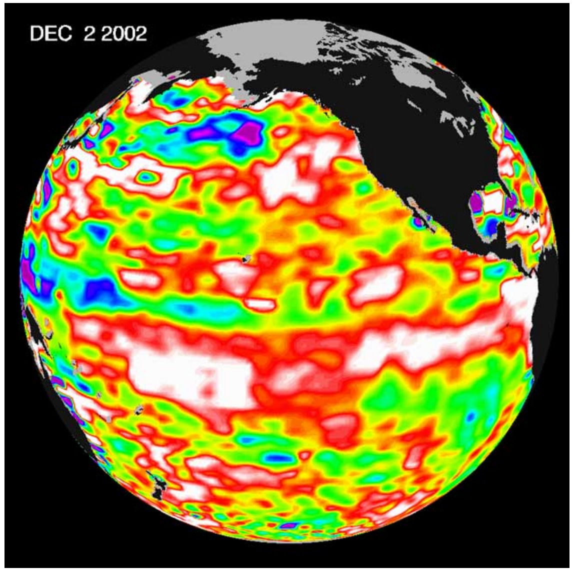


Image from http://sealevel.jpl.nasa.gov/elnino/